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Acid-Base Disorders Commonly Seen at a Tertiary Health Care Center

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Purpose: The purpose of this study was to identify the frequency of acid-base disorders at a tertiary health care center. ***Methods:*** Arterial blood gas (ABG) samples (n=180) were randomly selected from the medical and surgical intensive care units (MICU/SICU) at Loma Linda University Medical Center over a given four month period. Each sample was interpreted and descriptive statistics were generated. ***Results:*** Approximately 31% of ABG samples were normal. The most common acid-base disorder among both ICUs was simple respiratory alkalosis, occurring 39.2% out of all abnormal ABG results. Twenty-two percent of abnormal ABGs were found to be mixed acid-base disorders. There was no difference between the MICU and SICU when comparing normal, simple, or mixed acid-base disorders. ***Conclusion:*** Despite the results of our study, we do not recommend any changes in current curriculum or practice, nevertheless, educators and clinicians should be conscious that respiratory alkalosis was the most common acid-base disorder. Furthermore, mixed disorders occur with enough frequency that they must be a part of ABG education.

INTRODUCTION

Arterial blood gas (ABG) results are used to identify respiratory and metabolic acid-base disorders, and play an important role in the assessment and treatment of critically ill patients. It is common practice for intensive care unit (ICU) patients to have one or more ABGs each day, and more frequently, if the patient is mechanically ventilated. The purpose of this study was to identify the frequency of simple and mixed acid-base disorders in two specific ICUs in a tertiary medical center. The findings may have meaningful implications in that they may allow clinicians to emphasize the most common acid-base disorders in determining the differential diagnosis. Secondly, information ascertained from this study may also influence the educational content of healthcare programs.

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LITERATURE REVIEW

Acid-base disorders are common clinical problems resulting from a wide variety of pathophysiological conditions, such as pneumonia, renal failure, and diabetes.[1] They are classified as simple or mixed. Simple acid-base disorders include metabolic acidosis, metabolic alkalosis, respiratory acidosis, and respiratory alkalosis.[2] Mixed acid-base disorders result from a combination of two or more simple acid-base disorders. Healthcare professionals should be familiar with the various presentations of these acid-base disorders and the different approaches to their management for the following reasons: 1) Decisions about treatment are often based on the patient's acid-base status. 2) The results of the test may imply the presence of undiagnosed problems (R. L. Wilkins, PhD, oral communication, March 2004).

Treatment for the acid-base disorder is essential in preventing acute and long-term consequences of acid-base derangements.[1] History and physical examination are useful in the initial assessment of a patient's condition, however, acid-base disorders are primarily diagnosed on the basis of laboratory studies.[3,4] Some acid-base imbalances require rapid diagnosis and intervention to avoid disastrous outcomes.[3] Raffin[3] suggests if the clinician suspects that the patient has a significant aberration in oxygen or carbon dioxide gas exchange or acid-base balance, arterial blood gas analysis

is recommended. Common reasons for obtaining an ABG analysis include acute and chronic pulmonary disease, acute and chronic renal disease, and other metabolic disorders.[3] Moreover, serial arterial blood gas analyses are used with critically ill patients in intensive care units, as well as postoperative patients, and patients with chronic respiratory failure, who are not critically ill.[3]

ABG results are used to monitor a patient's progress; to adjust oxygen and other medication regimens; and to make management decisions concerning assisted ventilation, positive end-respiratory pressure, and weaning from ventilatory support.[3] Therefore, ABG evaluation is an integral part of patient assessment and determining the course of treatment, specifically for ICU patients. Wilkins (oral communication, March 2004) reports there is no descriptive research that identifies the frequency of possible acid-base disorders.

METHODS

We obtained arterial blood gas (ABG) results from Loma Linda University Medical Center's Medical (MICU) and Surgical (SICU) Intensive Care Units. The results were acquired from a computerized blood gas analysis instrument (Bayer 855), which analyzes oxygenation and ventilation of arterial blood. It provides data on the following factors:

- Hydrogen ion concentration (pH)
- Partial pressure of arterial carbon dioxide ($PaCO_2$)
- Partial pressure of arterial oxygen (PaO_2)
- Arterial blood bicarbonate (HCO_3^-)
- Base excess (BE)

We collected data from December 2003 to April 2004 and limited data to ABG results upon admission to the MICU or upon post-operative admission to the SICU.

Random sampling was used to select our sample from a total of 396 results in the SICU and 247 results in the MICU. We utilized Sample Power (version 2.0, obtained from SPSS, Inc.) to calculate the sample size needed from each ICU. We chose to have a 5% Type I error with 80% power. In order to compare frequency as a proportion among the normal and abnormal (simple and mixed) acid-base disorders, we collected 90 samples from each ICU. Patient confidentiality was assured by removing the patient's medical record number and name and by assigning each ABG result a new identification number.

After the ABG samples were acquired, a critical care physician analyzed each sample for an official interpretation. A mixed acid-base problem is present when the predicted compensation is not present. See Table 1 for expected compensation for acid-base disorders. Each sample was classified as either a simple or mixed acid-base disorder or as being normal.

The data was analyzed using the Statistical Package for the Social Sciences software (SPSS, version 12.0).[6] Frequencies and relative frequencies were calculated for simple and mixed acid-base disorders and those with normal findings found in the MICU and SICU. The proportions of normal, simple, and mixed acid-base disorders were compared between MICU and SICU using the Chi-square test for homogeneity.

Table 1. Summary of Expected Compensation for Acid-Base Disorders[1]

Primary Disorder	Expected Compensation
Acute Respiratory Acidosis	For a 15 mm Hg increase in $PaCO_2$, the HCO_3 increases 1 mEq/L
Chronic Respiratory Acidosis	For every 10 mm Hg the $PaCO_2$increases, the HCO_3 increases 4 mEq/L
Acute Respiratory Alkalosis	For every 5 mm Hg decrease in $PaCO_2$, HCO_3 decreases 1 mEq/L.
Chronic Respiratory Alkalosis	HCO_3 falls 5 mEq/L for every 10 mm Hg fall in $PaCO_2$.
Metabolic Acidosis	$PaCO_2$= last two digits of pH; $PaCO_2 = (1.5 \times HCO_3) + 8 \pm 2$
Metabolic Alkalosis	For each 1 mEq/L increase in HCO_3 $PaCO_2$ increases 0.6 mm Hg

RESULTS

Among the combined SICU and MICU patients, 30.6% (n=55; 27 in MICU and 28 in SICU) had normal ABGs and 69.4% (n=125) had abnormal ABGs indicating a simple or mixed acid-base disorder. Of those ABGs that were abnormal, 77.6% (n=97) were simple acid-base disorders; 47 in the MICU and 50 in the SICU. Of the abnormal results, the percent of mixed acid-base disorders was 22.4% (n=28); 16 in the MICU and 12 in the SICU (see Figure 1).

Analysis showed that the proportions of simple and mixed disorders were similar in both ICUs (χ^2=0.66; p=.42). Of all simple disorders from both ICUs, 64.9% (n=63) were respiratory disorders and 35.1% (n=34) were metabolic disorders. Forty-nine percent (n=31) of the respiratory disorders occurred in the MICU and 51% (n=32) occurred in the SICU. Of the metabolic disorders, 47% (n=16) occurred in the MICU and 53% (n=18) occurred in the SICU (Figure 2). Respiratory alkalosis was found significantly more often than any other disorder occurring as 39.2% of all abnormal results (χ^2=48.0; p=<001). Figure 3 shows the specifics of each simple and mixed acid-base disorder occurring in each ICU. Overall, the proportions of normal, simple, and mixed acid-base disorder between the MICU and SICU were similar (χ^2=0.72; p=.87).

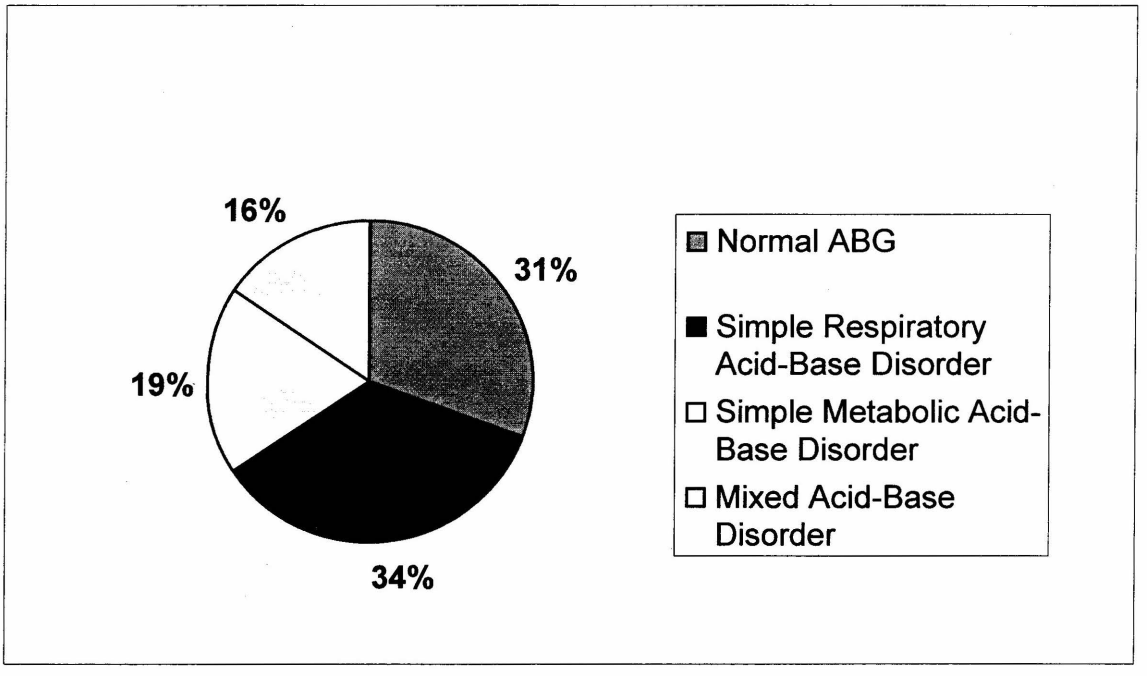

Figure 1. Normal vs abnormal acid –base disorders in the medical and surgical intensive care units (n=180).

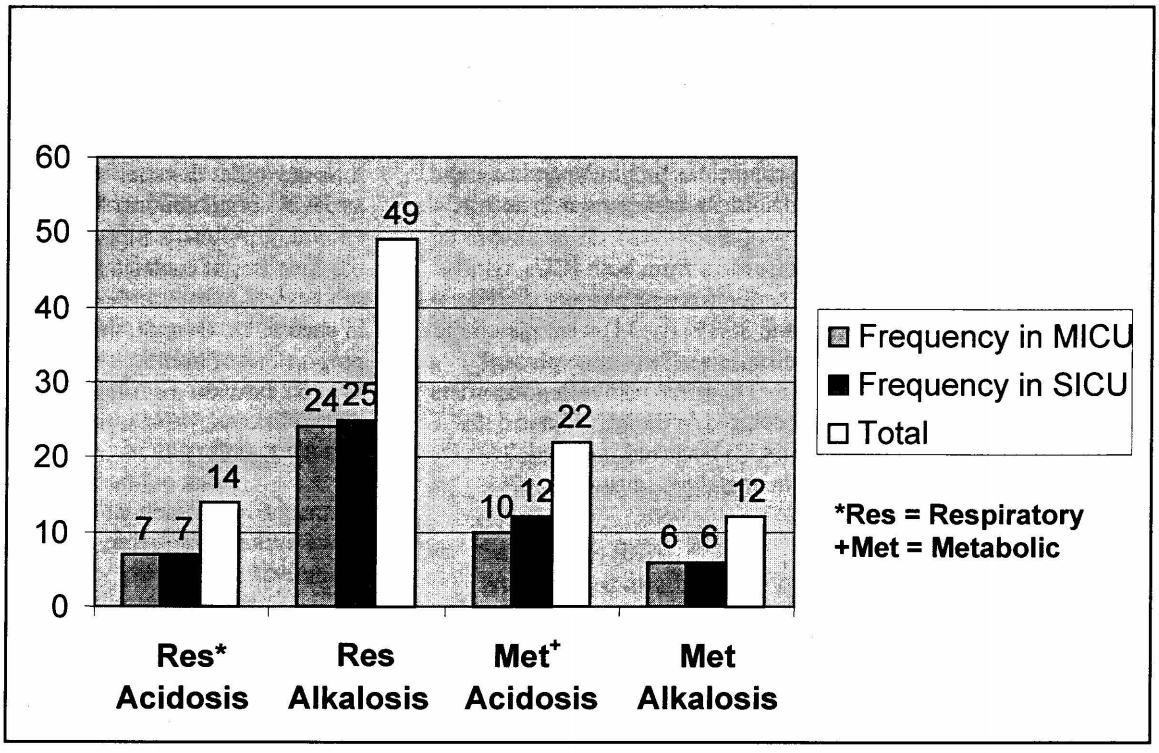

Figure 2. Simple acid-base disorders in the medical and surgical intensive care units.

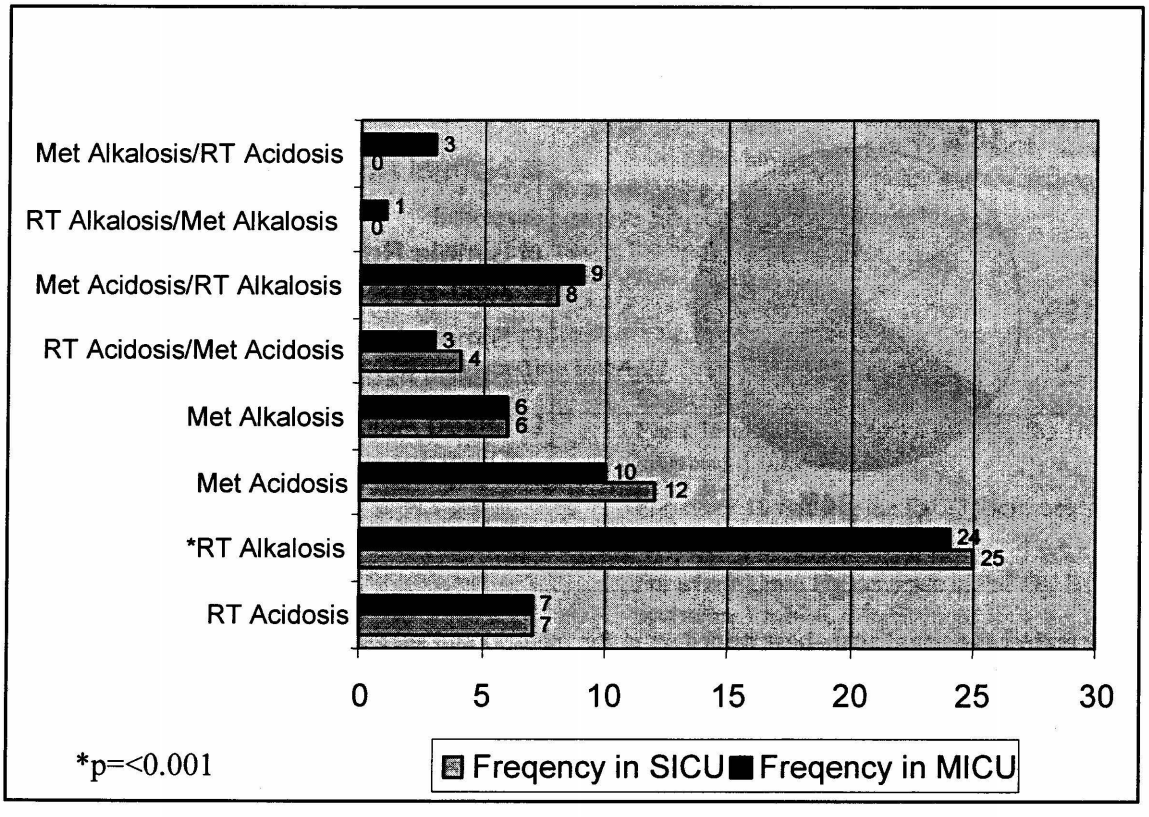

Figure 3. Frequency of simple and mixed acid-base disorders in the medical and surgical intensive care units.

DISCUSSION

Studies in the past have not identified the frequency of acid-base disorders in intensive care units. Our study showed that there was no difference between the medical and surgical intensive care units when comparing acid-base disorders. Respiratory alkalosis was the most frequent overall acid-base disorder found. Among the mixed disorders, metabolic acidosis and respiratory alkalosis was most common, occurring twice as frequently as other mixed acid-base disorders.

One explanation for the results of the study is that patients who undergo ABG puncture may tend to hyperventilate causing respiratory alkalosis. Mechanical ventilation may explain why respiratory alkalosis is common because the patient may be hyperventilated by high tidal volumes or an increased frequency compared to spontaneous breathing. Being hospitalized in itself may contribute to hyperventilation due to anxiety and pain. The presence of acute and chronic renal patients may explain why metabolic acidosis and respiratory alkalosis was the most common mixed acid-base disorder. Further research should be done to identify the frequency and correlation of certain acid-base disorders and diseases.

Our literature review indicated that our study is the first study to identify the frequency of simple and mixed acid-base disorders in a tertiary medical center. An additional strength of our study was random sampling. This method was used to control bias and may have contributed to why there was no difference in the distribution of acid-base disorders between the two ICUs.

Limitations of our study included sample size and seasonal variation. A study identifying consecutive ABGs in a specified time period may reflect different results than this study. Secondly, our sample size did not allow for detailed analysis of the frequency of mixed acid-base disorders. Therefore, we recommend a larger sample size in future studies if specific simple or mixed acid-base disorders are to be analyzed. Lastly, variables such as the length of study time, seasons of the year, and diseases prevalent during that time period may have affected the results. Consideration of these variables in future studies may result in more generalizable conclusions.

The outcome of this study may be used in conjunction with the current knowledge and teachings of acid-base disorders. Since the most common acid-base disorder among both units was respiratory alkalosis, educators can emphasize diseases and conditions associated with this disorder. Clinicians should also be taught to recognize mixed acid-base disorders, since they occurred in 22.4% of the abnormal cases.

CONCLUSION

We do not recommend any changes in curriculum, assessment, or treatment of a patient because our study was to determine frequency and is solely limited to educational purposes. Educators and clinicians should be conscious that respiratory alkalosis was the most common acid-base disorder.

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